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Meyer, Knud Erik; Velte, Clara Marika; Jaunet, V.; Bøtkjær, N. ; Hess, D.

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K. E. Meyer[a], C. M. Velte[a], V. Jaunet[b], N. Bøtkjær[b] and D. Hess[b]

Vortex generators are small passive devices placed in a boundary layer with the purpose of delaying or avoiding flow separation. They are commonly assumed to generate longitudinal vortices that enhance transport of momentum towards the wall and are applied on e.g. aircrafts, wind turbines and diffusers. Relatively recent studies have shown that they also increase turbulent mixing which can often be very efficient indeed[1]. There have been numerous studies of vortex generators[1], but flow dynamics and interaction with boundary layer turbulence is still not understood in detail. The present study looks at vortex generators on a plate with a turbulent boundary layer and almost negligible streamwise pressure gradient. No separation is expected and the focus is the dynamical flow structures behind the vortex generators. A relatively new measurement technique, Tomographic Particle Image Velocimetry (PIV), provides all velocity components in a three-dimensional grid. Another purpose of the study is to test this technique on a relatively complex (3D), but still fairly well understood flow[2,3].

A plate mounted in a wind tunnel is fitted with vortex generators with a height h=5 mm, a rectangular shape, a counter-rotating configuration and an angle with respect to the main flow direction of 18°. The wind tunnel speed is 10 m/s and the boundary layer thickness just before the vortex generators is 1.5h. A region from the wall to a distance 2h above the wall is illuminated downstream of the vortex generators with a pulsed Nd:YAG laser. Glycerol droplets with a diameter of about 2 μm are imaged into four different 4 Megapixel cameras looking at the same region from different angles. The images are processed into instantaneous velocity fields using Dantec DynamicStudio with Least Square Matching (LSM) instead of cross correlation. An example of a part of a measured instantaneous flow field is shown in figure 1.

The results confirm the expected existence of clearly identifiable longitudinal counter rotating vortices[1,2,3]. These result in streaks of high and low velocity at quite fixed positions. However, the magnitude of these high and low velocities varies a great deal in time. Analysis with Proper Orthogonal Decomposition (POD) suggests that this is the most important dynamic variation of the flow.

[a] Dep. Mechanical Engineering, Technical University of Denmark, Lyngby, Denmark

[b] Dantec Dynamics, Skovlunde, Denmark

[1] JC Lin, *Progress in Aerospace Science.* **38**, 389-420 (2002).

[2] CM Velte, MOL Hansen, VL Okulov, *Journal of Fluid Mechanics.* **619**, (2008).

[3] CM Velte, *AIAA Journal.* **51**, 2, 526-529 (2013).

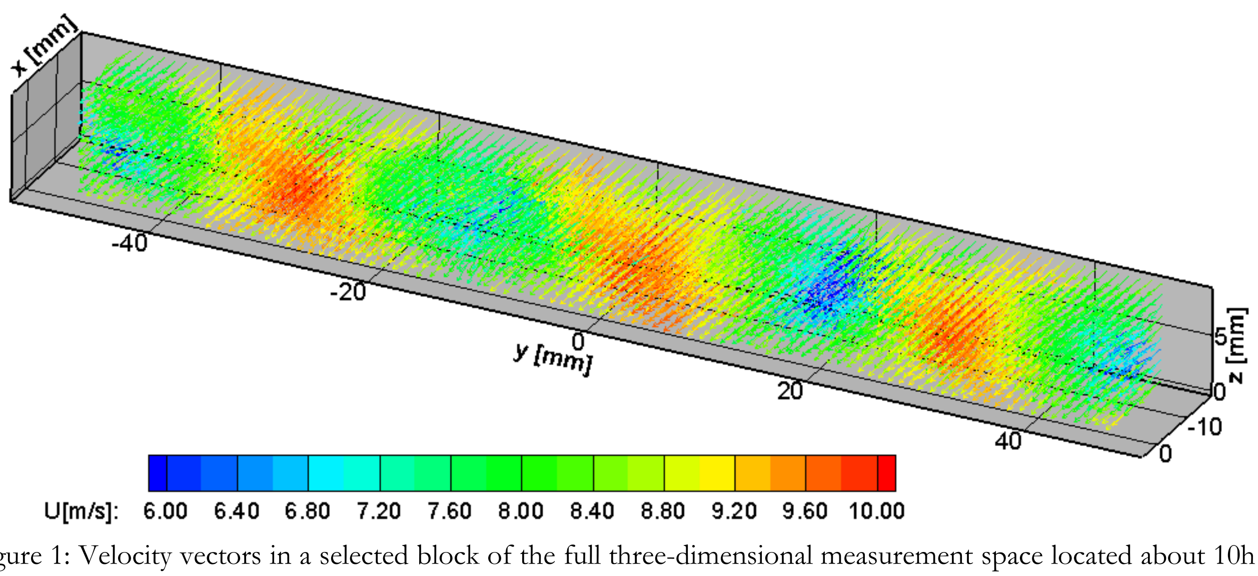

Figure 1: Velocity vectors in a selected block of the full three-dimensional measurement space located about 10h downstream of the VGs. Colour indicates the streamwise velocity component U in the main flow direction x.